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Title: Mshock, a thin layer Richtmyer-Meshkov instability experiment

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Mshock, a thin layer Richtmyer-Meshkov instability experiment



Tiffany Desjardins

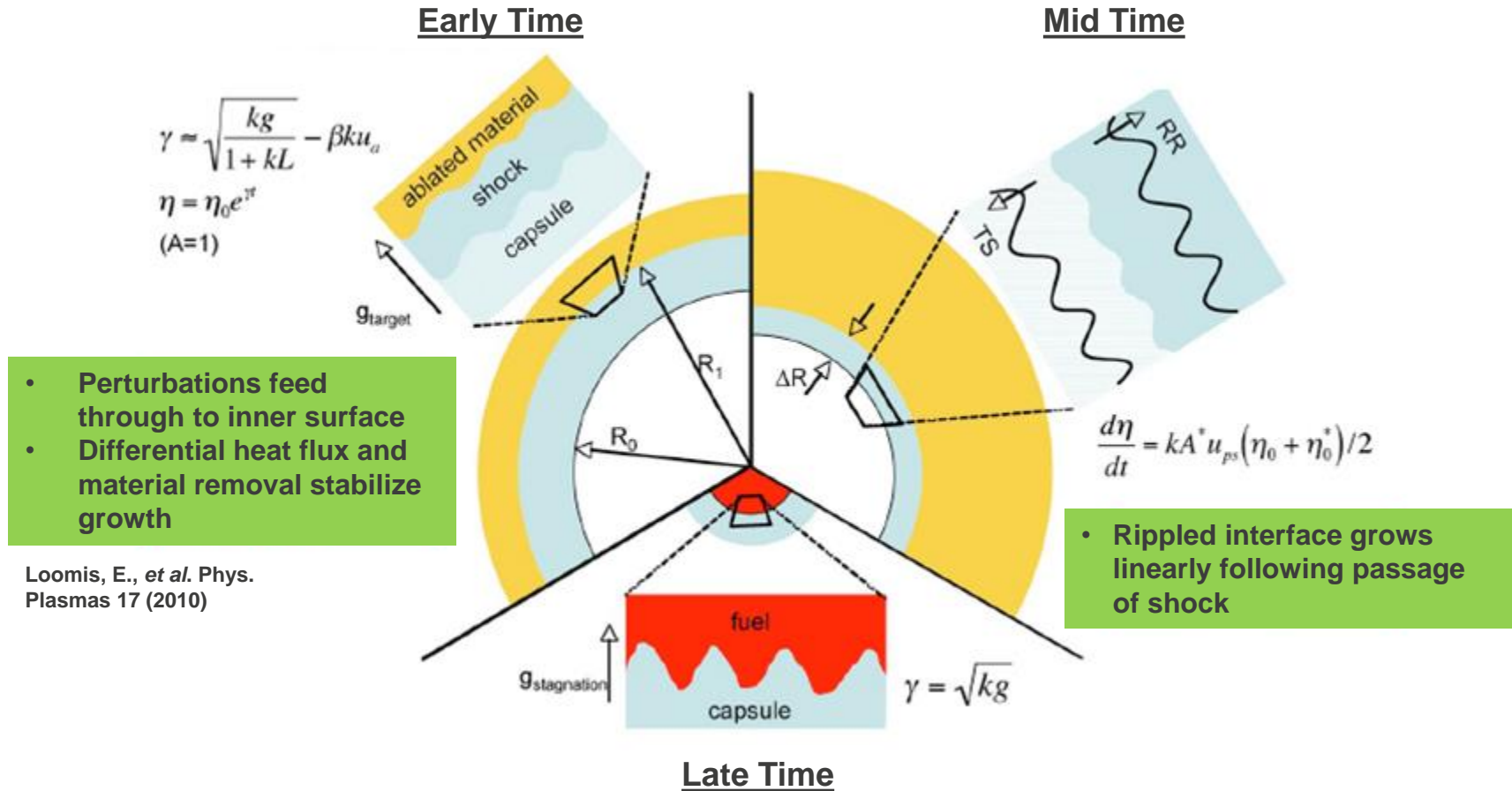
July 20, 2018

Carlos Di Stefano, Elizabeth Merritt, Kirk Flippo,
Barbara DeVolder, Forrest Doss and John Kline

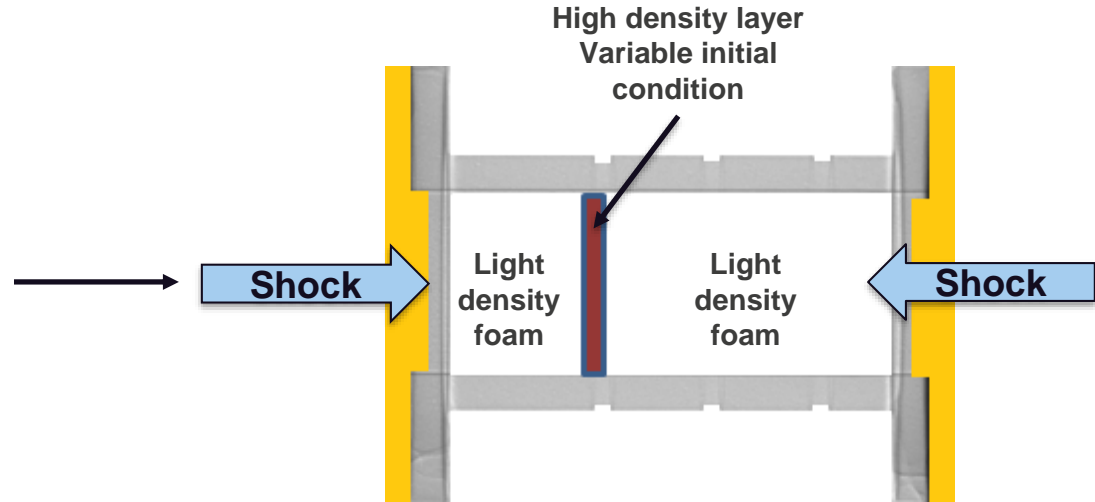
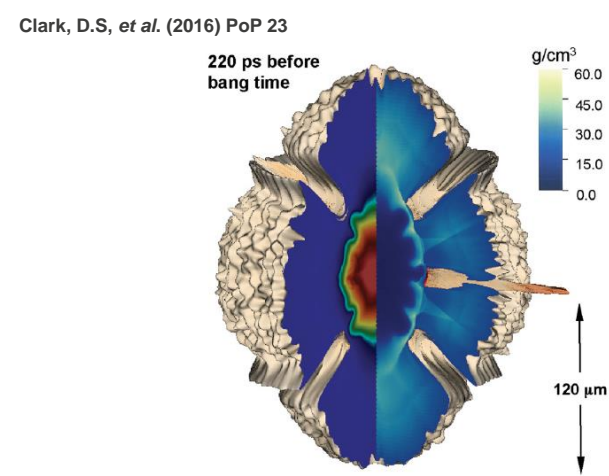


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Fluids instabilities cause *mixing* in ICF capsules, which leads to fuel degradation and reduction of yield



The Multi-shock (*Mshock*) platform was designed to study the Richtmyer-Meshkov instability similar to an ICF capsule



- Instabilities in ICF capsule is a 3D problem with:

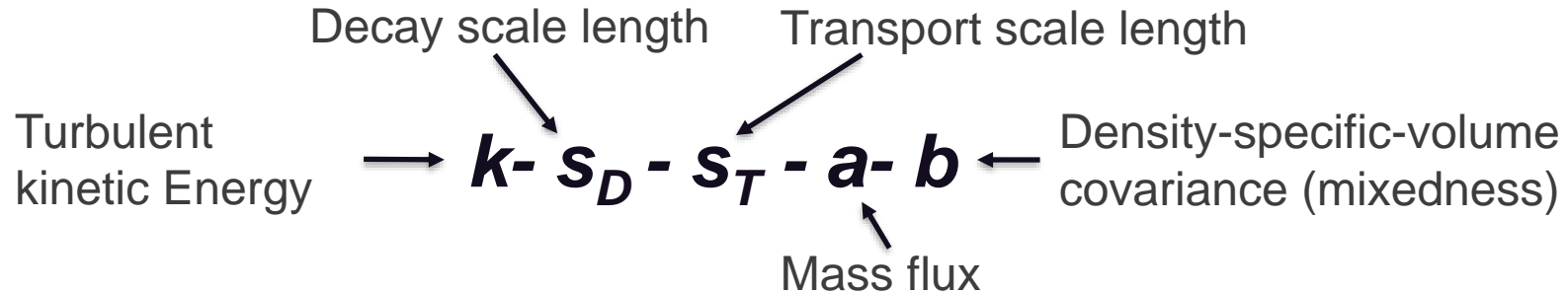
- Drive asymmetries
- Compression effects
- Capsule imperfections
- Fill tube and tent effects

Moving to planar geometry:

- Improves resolution
- Easier to diagnose
- Easier to control

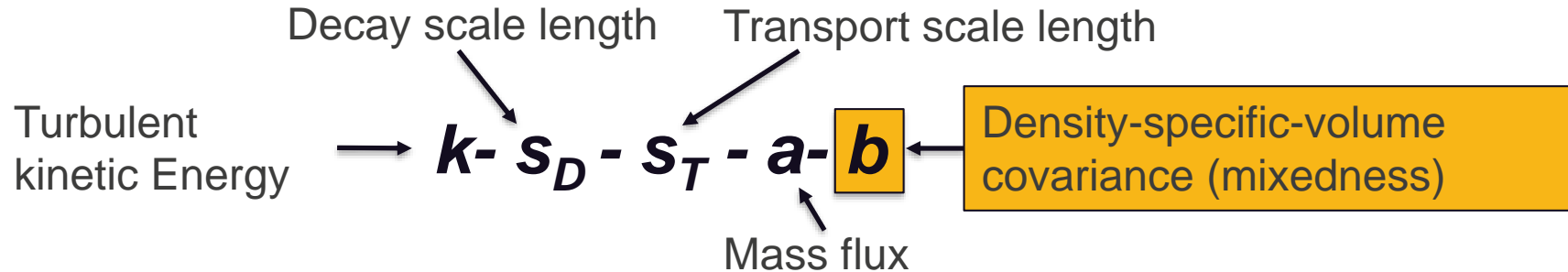
Mshock results are compared with the Besnard-Harlow and Rauenzahn (BHR) mix model

- BHR is currently a two-length scale turbulence model¹ implemented in RAGE fluid code



Mshock results are compared with the Besnard-Harlow and Rauen Zahn (BHR) mix model

- BHR is currently a two-length scale turbulence model¹ implemented in RAGE fluid code



Mshock is designed to compare mixing with the BHR model parameter b

We developed the platform to meet these requirements

- **To relate back to the BHR mix model:**
 - Density to relate to model parameter b
- **To study Richtmyer-Meshkov in HED regime and relate back to ICF:**
 - Multiple shocks and their effect on mixing
 - Initial conditions and their effect on mixing

OMEGA laser facility has large shot rate, but low resolution, while NIF has good resolution but low shot rate



- OMEGA 60

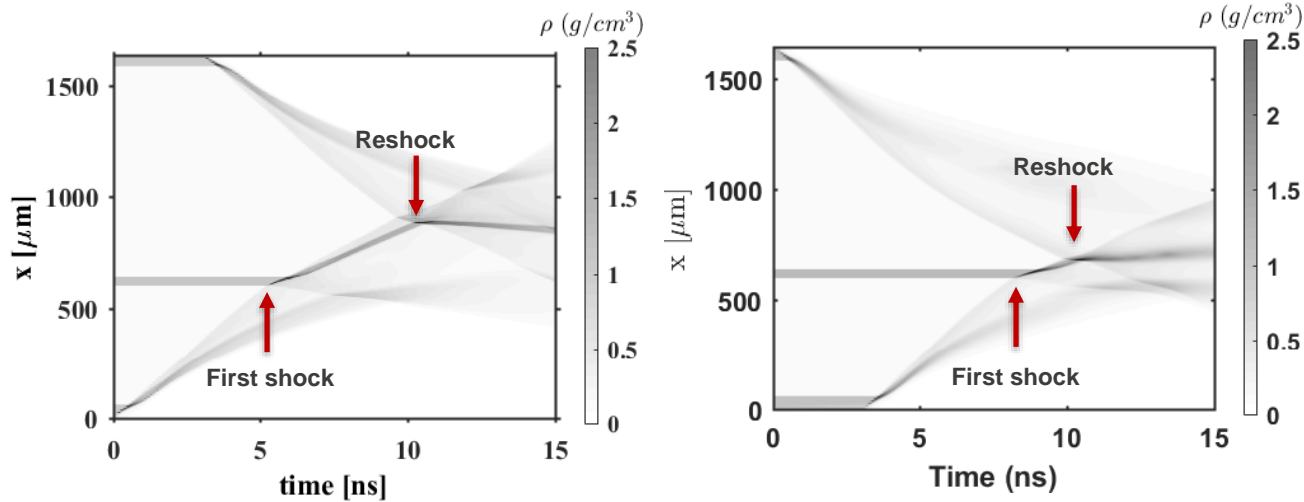
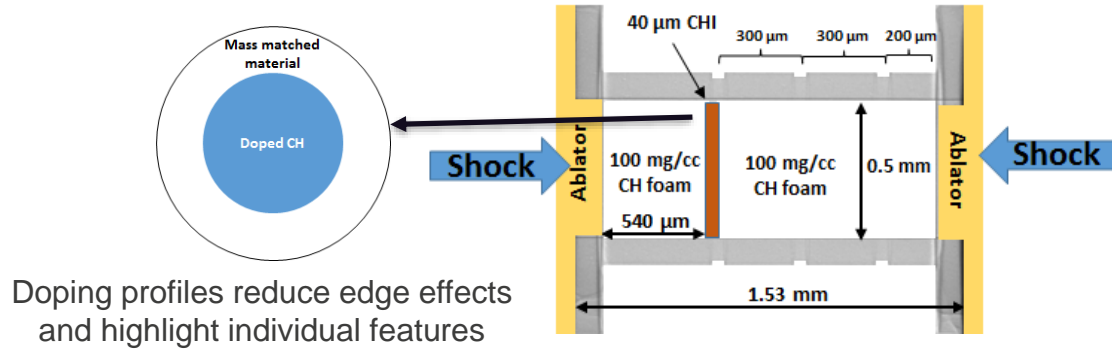
- 60 Beams
- 500 J per beam, 1 ns pulse, up to 30 kJ
- 14-16 shots/day
- 2-4 days/year

- NIF

- 192 Beams
- Energy, length and shape of pulse variable, up to 2MJ
- 2-3 shots/day
- 2-4 days/year

OMEGA is needed for platform development, but
NIF is required for the final experiment

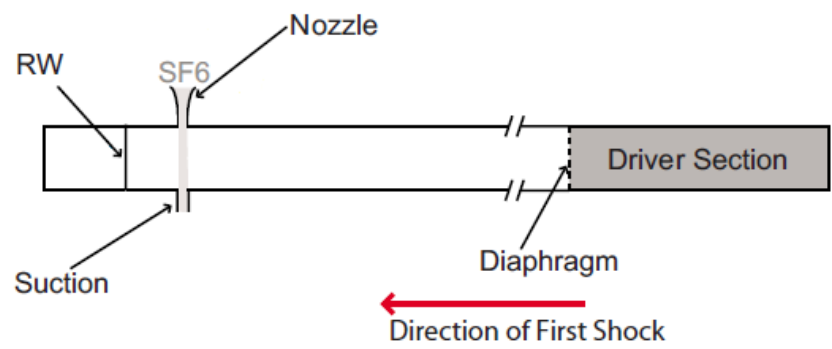
Mshock is optimized to study RMI growth under a variety of shock and re-shock timings



This will allow us to do studies similar to fluids experiments

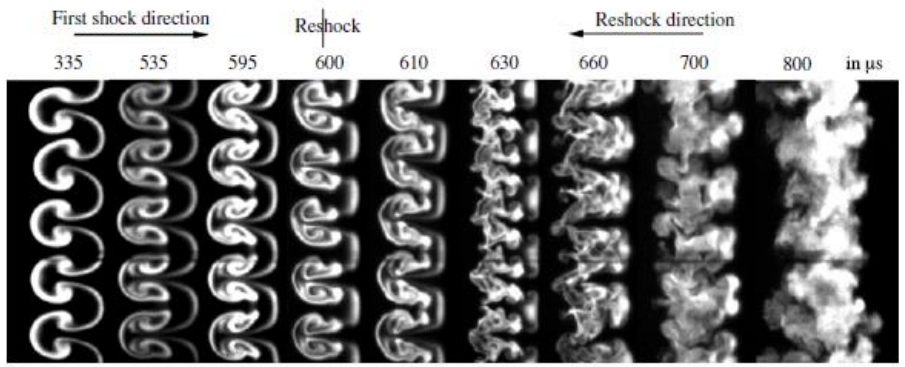
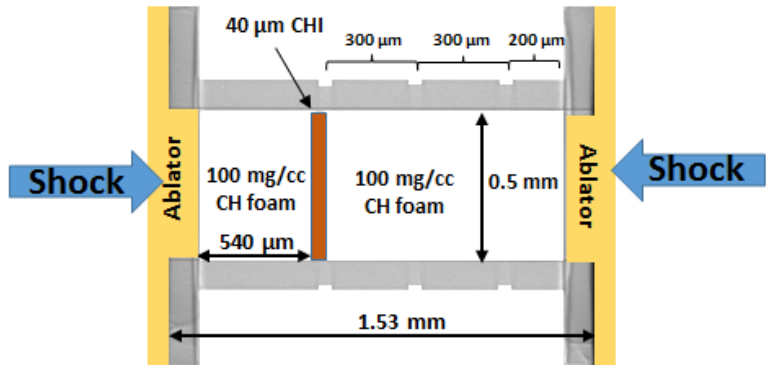
Mshock design is very similar to horizontal shock tube experiments and may allow for scaled experiments

Horizontal Shock Tube

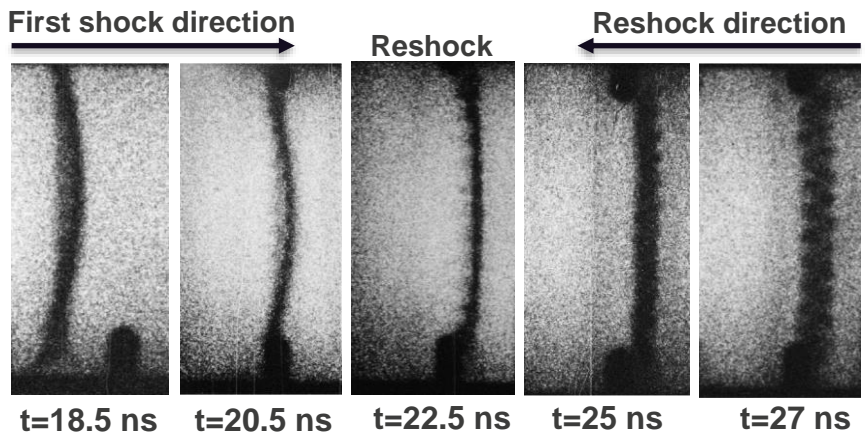


1. Balakumar, B. J., *et al.* Phys. Fluids (2008) 20

MShock Campaign



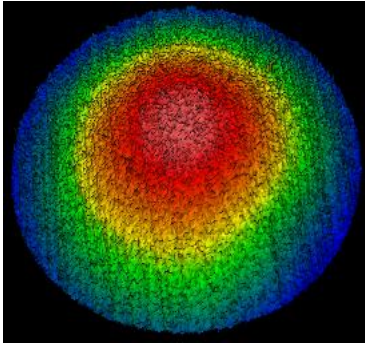
2. Tomkins, C. D., *et al.* J. Fluid Mech. (2013) 735



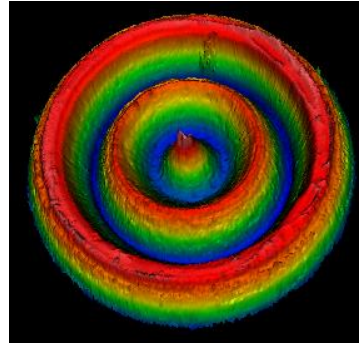
We can use lessons learned from fluids experiments to inform our design

We are able to control the initial conditions of the high density layer to study the effects on mixing

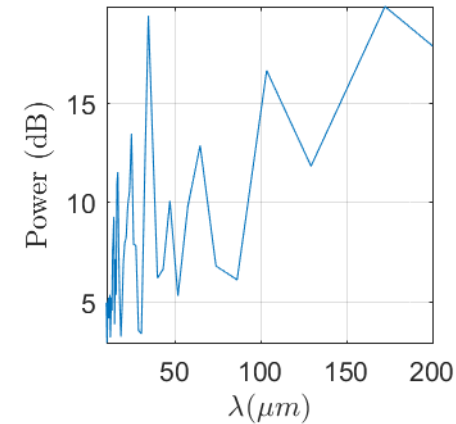
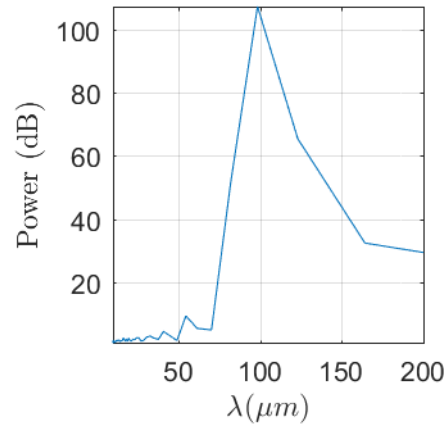
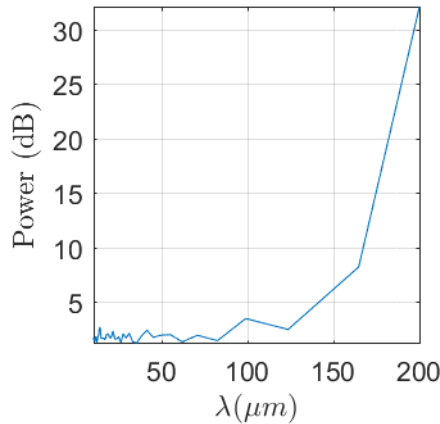
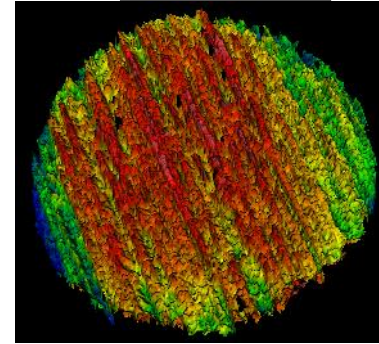
Smooth



Coherent



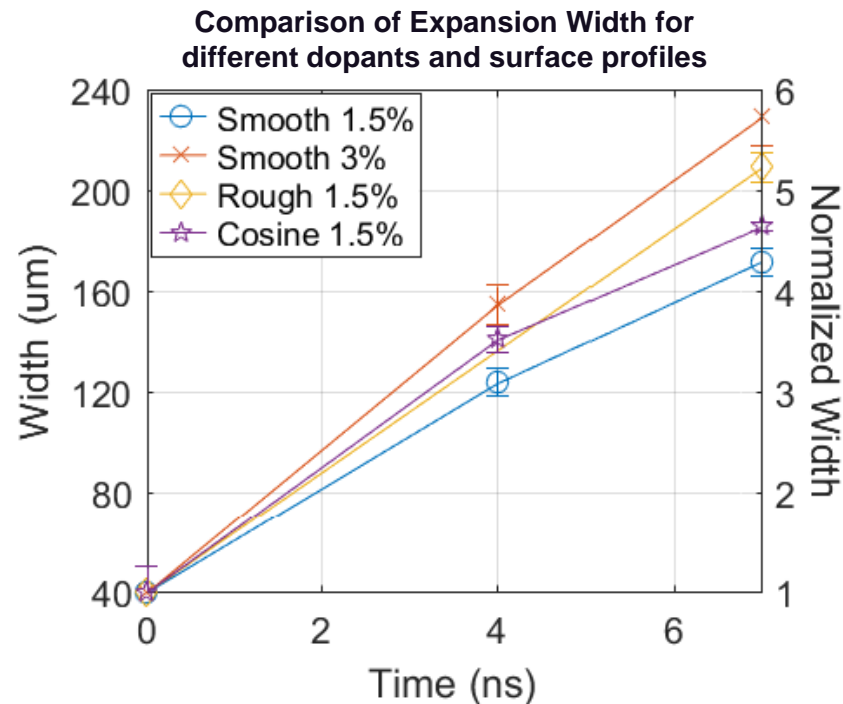
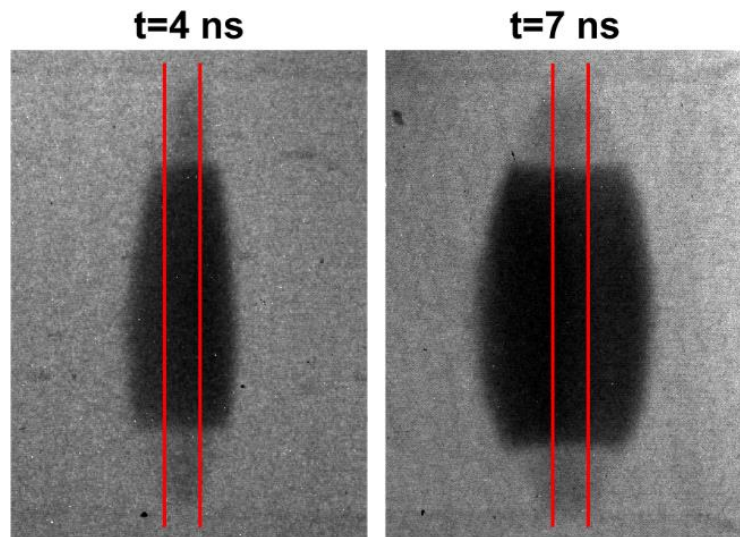
Broadband



Mshock has precise measurement and control of initial conditions

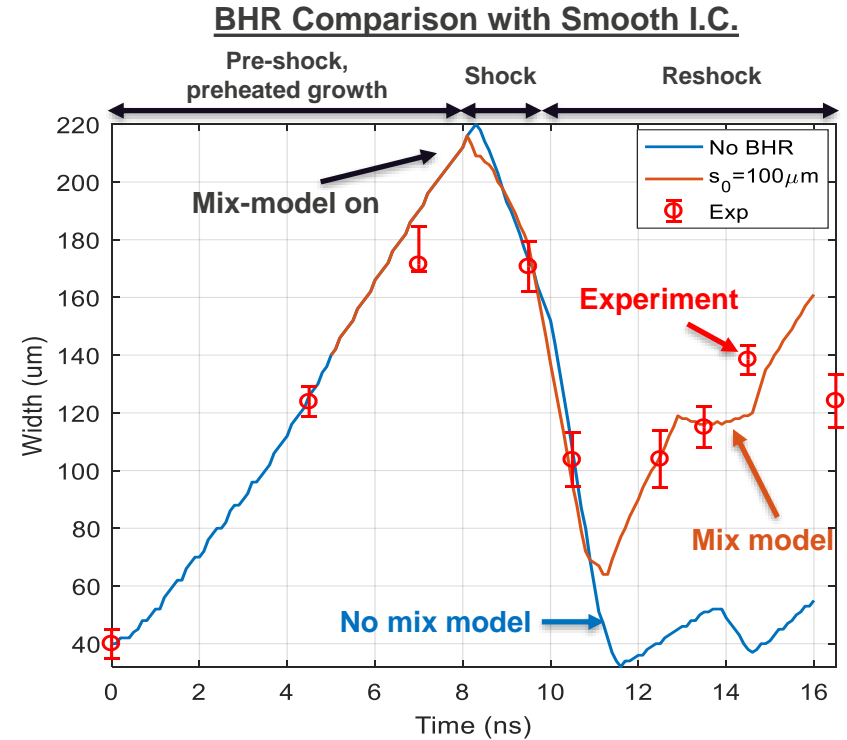
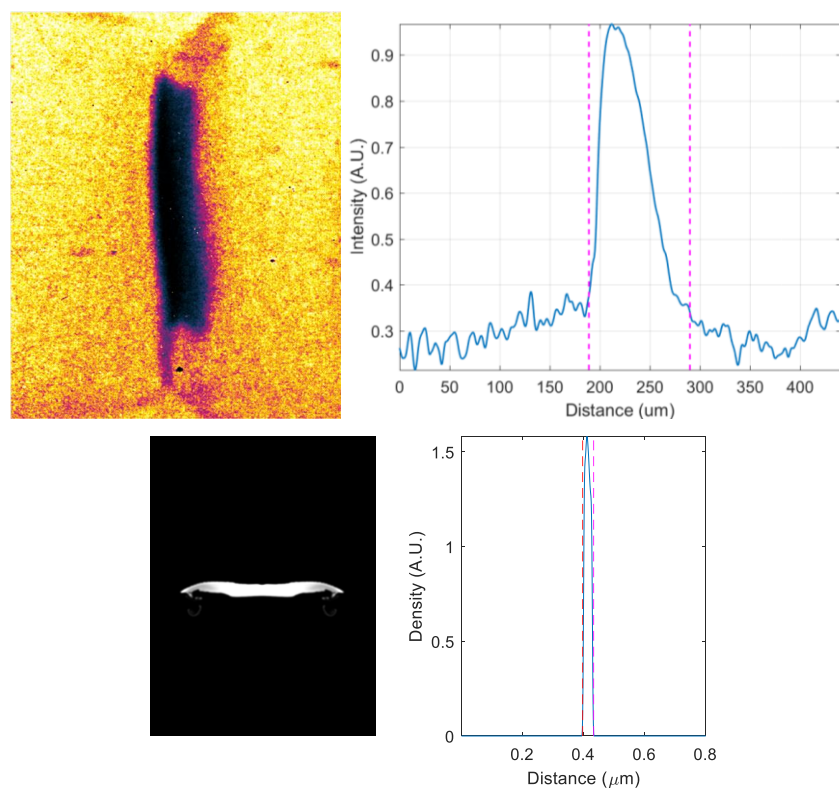
The OMEGA campaign is highly impacted by preheat effects, which changes the experiment

Di Stefano, C. A., et al. Phys. Rev. E. 95 (2017)



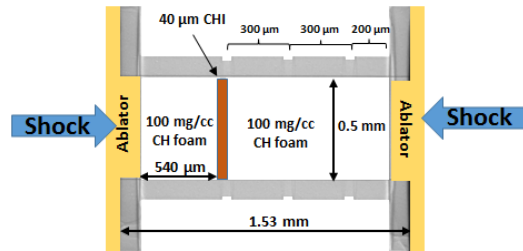
Experiments last week were designed to diagnose and damp preheat effects

OMEGA comparisons with BHR are limited to layer width, but still indicate that mixing is occurring

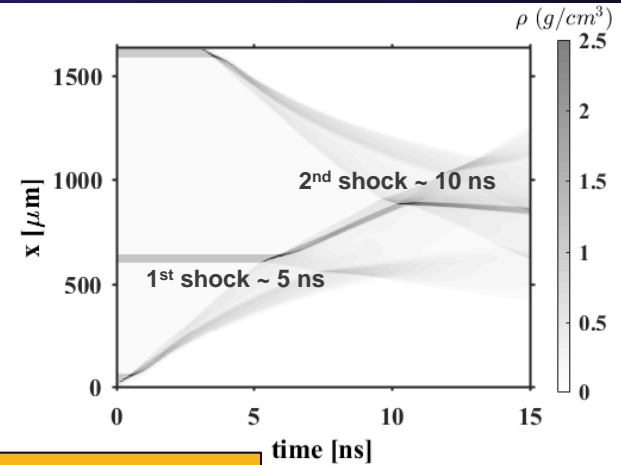
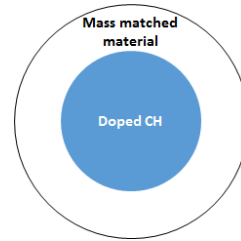


The OMEGA campaign has successfully laid the foundation for NIF experiments, which are currently underway

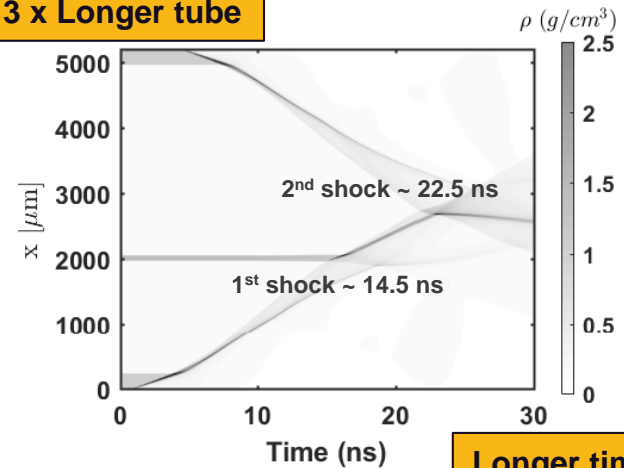
NIF experiments are scaled from OMEGA, with improved resolution, longer experimental time with supported shocks



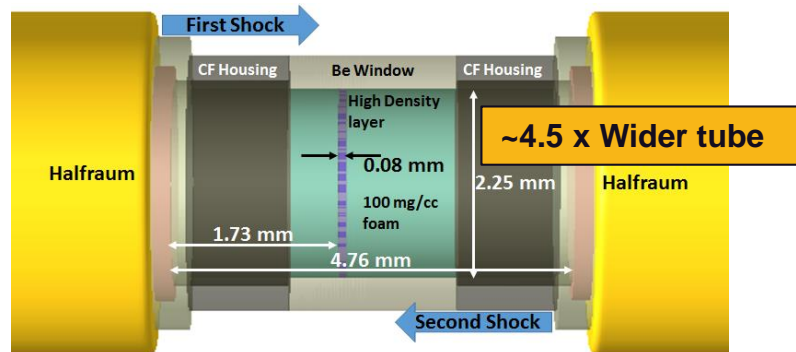
Shock speed: $\sim 90\text{-}100\text{ }\mu\text{m/ns}$
($M_{pl} \sim 18\text{-}20$)



$\sim 3 \times$ Longer tube

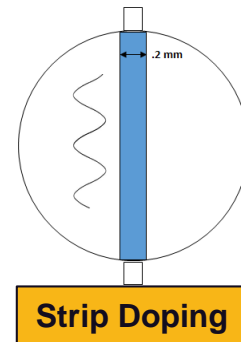


Longer time



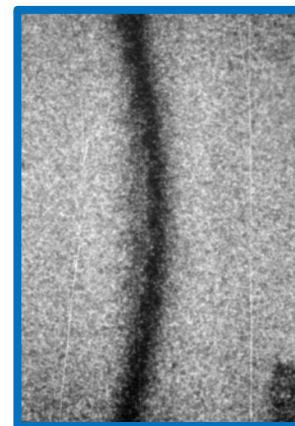
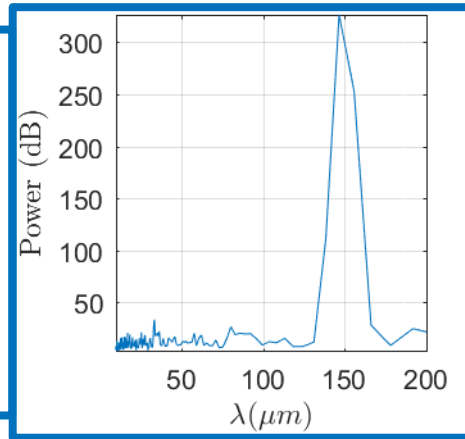
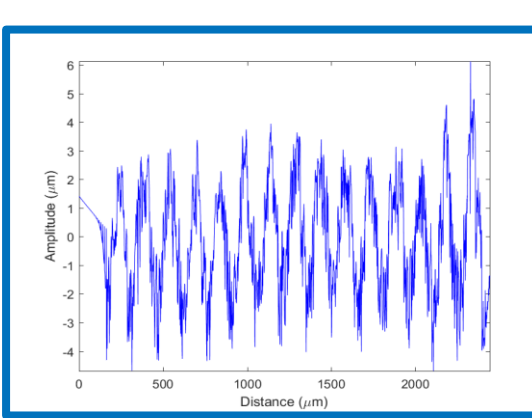
Shock speed: $\sim 140\text{ }\mu\text{m/ns}$
($M_{fl} \sim 14$, $M_{pl} \sim 28$)

Stronger shock

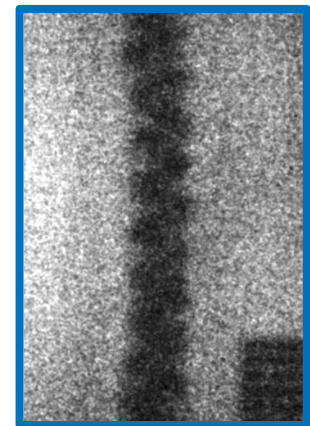


Strip Doping

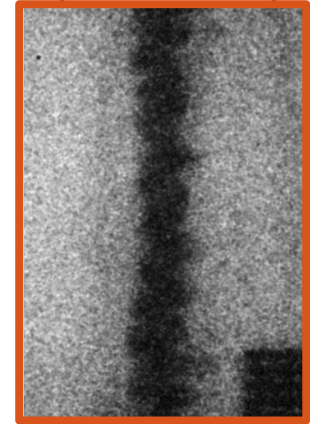
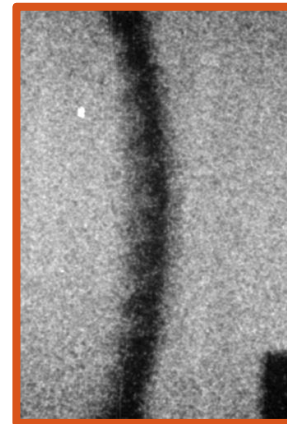
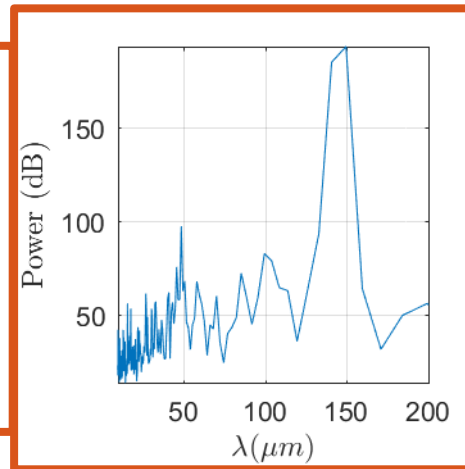
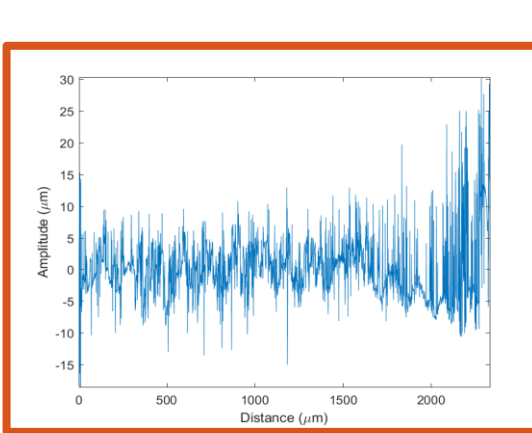
NIF Mshock has shown that we can vary the instability growth by changing our machined initial conditions



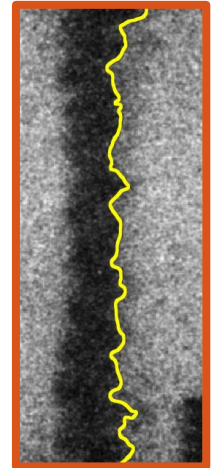
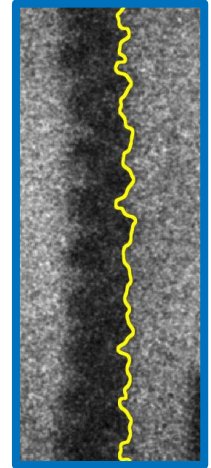
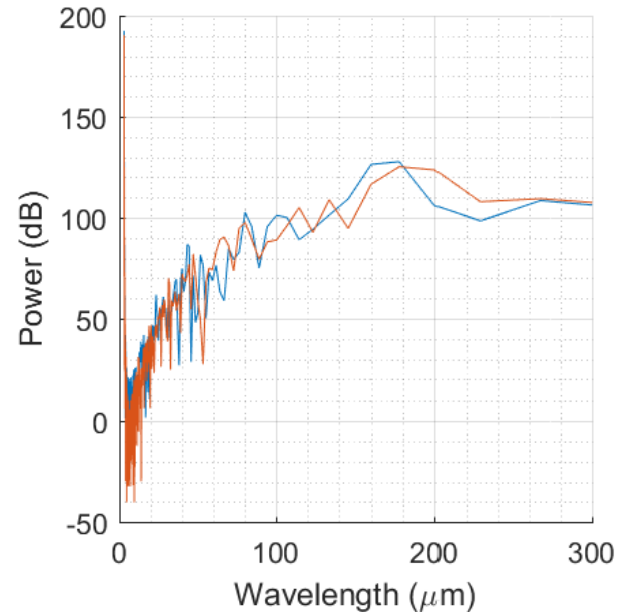
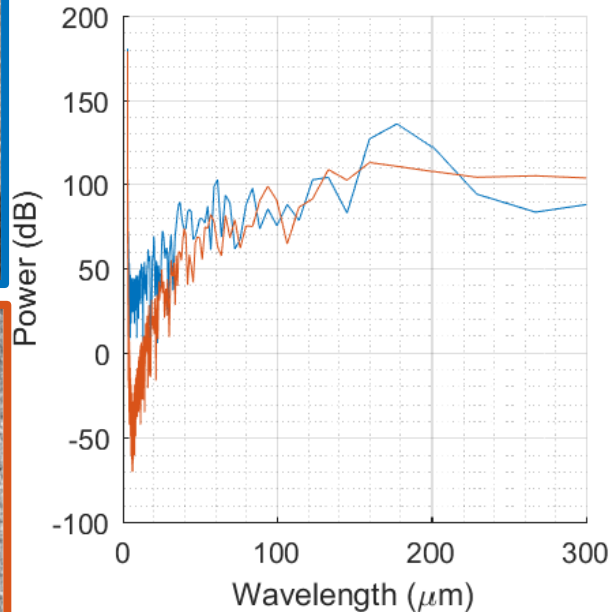
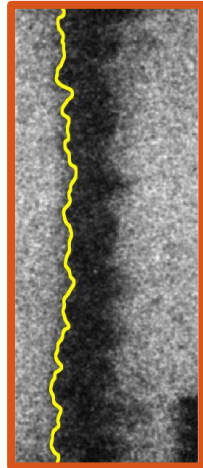
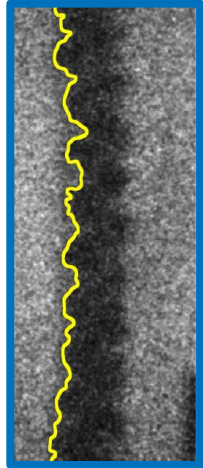
$t = 20.5 \text{ ns}$
(Post-shock)



$t = 27 \text{ ns}$
(Post-reshock)



We are in the process of developing techniques to quantify growth and mixing of the layer

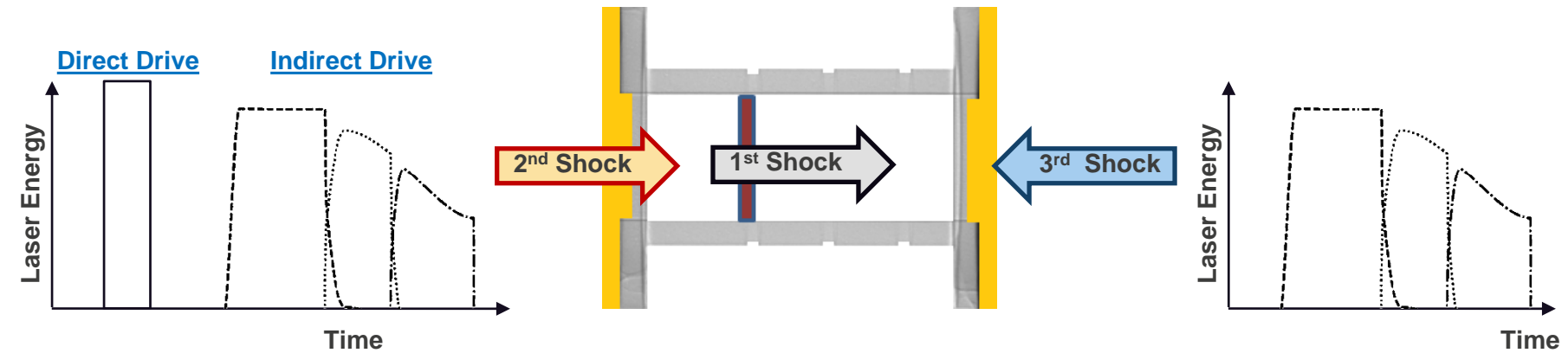


Results indicate that initial conditions persist and affect the mixing

NIF *Mshock* will be a multi-shock Richtmyer-Meshkov instability experiment

- New drive setup will allow us to study:

- Co-propagating shock to re-shock
- Shock merger
- Shock interaction with varying shock strength
- Affects of re-shocking with up to 3 shocks



First test of drive scheme was on July 10-11th

The OMEGA campaign has successfully laid the foundation for NIF experiments, which are currently underway

- **OMEGA Mshock has provided platform development for NIF**
 - Doping profiles
 - Machining initial conditions
 - First comparisons with BHR
- **First comparisons between OMEGA and BHR indicate that mixing is occurring**
- **NIF experiments are exhibiting different growth and mixing based on initial conditions**
 - Detailed analysis in development
- **Future NIF experiments will use 3-4 shocks**

Thank you!